POTENTIALS FOR He⁺ + Ar and He⁺ + Ne DEDUCED FROM ELASTIC SCATTERING DATA

Felix T. Smith

Stanford Research Institute, Menlo Park, California 94025

In the classical impact parameter approximation for spherically symmetric scattering the reduced differential cross section .

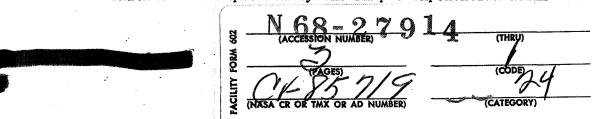
$$\rho = \theta \sin\theta \sigma(\theta, E)$$

is a function only of the reduced scattering angle

$$\tau = E\theta$$

with correction terms that are negligible in forward scattering.¹ We have replotted together two sets of data for the elastic scattering of He⁺ on Ne and Ar: the results of Aberth and Lorents² in the energy range 10 to 600 eV and those of Fuls, Jones, Ziemba and Everhart³ in the range 25 to 100 keV. In the latter case we have employed the total pseudoelastic cross section (irrespective of the final charge state or excitation level of the He) as best representing the deflection of the projectile He⁺⁺ as it passes through the field of the scatterer. The data show great internal consistency, providing empirical confirmation of the scaling law and allowing the potential to be deduced.

Over a very extensive part of the whole range, the scattering data can be reproduced very well by a simple screened coulomb repulsive interaction. Effects of shell structure are prominent in the screening, which can be expressed by the simple exponential forms



CFSV; H.C. + 300

$$V_{\text{rep}}(Ar) = \frac{2e^{2}}{r} \begin{bmatrix} 8e^{-r/c_{M}} & -r/c_{L} & -r/c_{K} \\ 8e^{-r/c_{L}} & + 2e^{-r/c_{K}} \end{bmatrix},$$

$$V_{\text{rep}}(Ne) = \frac{2e^{2}}{r} \begin{bmatrix} 8e^{-r/c_{L}} & -r/c_{K} \\ 8e^{-r/c_{L}} & + 2e^{-r/c_{K}} \end{bmatrix}.$$
(1)

In Table I we compare the screening lengths c deduced from these data with the predictions of a simple hydrogenic model in which they are related to the closed-shell ionization potentials I;:

$$c_i = a_0 (I_H/I_i)^{1/2}$$
 (2)

		Table I	
	Shell	(c _i /a _o) _{exp}	(c _i /a ₀) _{calc}
Ar	M	.90	.93
	L	.14	.18
	. K	$\ll c_{ m L}$.057
Ne	L	.70	.79
	K	.055?	.107
			the second secon

At small reduced angles, the scattering data deviate from the pure repulsive scattering predicted by (1) in the direction corresponding to an attractive force, and the ${\rm He}^+$ - Ar data show a clear rainbow feature at ${\rm T_r}=32$ eV-deg from the same source. We have tried to fit (a) the deviation from the simple repulsive curve and (b) the rainbow angle ${\rm T_r}$ by using a polarization term with screening as the outermost shell of the target is penetrated:

$$V_{pol} = -\frac{\alpha e^2}{r^4} \left[1 - e^{-r/c_{j}} (1 + \frac{r}{c_{j}} + \frac{r^2}{2c_{j}^2} + \frac{r^3}{6c_{j}^3}) \right], \qquad (3)$$

where $c_j = c_M(Ar)$, = $c_L(Ne)$. The resulting estimates of the polarizability α are given in Table II and compared with Dalgarno and Kingston's calculated values.⁴

	Table II		
α(rai	nbow) α(devi	iation) α (calculated)
Ar 1.8	35 Å ³ 1.65 ±	± .10 ų	1.64 Å ³
Ne -	41 :	± .04 ų	.395 ų

References

F. T. Smith, R. P. Marchi, and K. G. Dedrick, Phys. Rev. 150, 79 (1966)

² W. Aberth and D. C. Lorents, Phys. Rev. 144, 109 (1966)

³ E. N. Fuls, P. R. Jones, F. P. Ziemba, and E. Everhart, Phys. Rev. 107, 704 (1957)

⁴ A. Dalgarno and A. E. Kingston, Proc. Roy. Soc. A259, 424 (1960)